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CLAIM AMENDMENTS

1. (currently amended) A method for restoring a geometrically distorted copy of a reference image, said method comprising:

automatically determining a type and amount of distortion of said distorted copy, without extracting a registration signal;

substantially reversing the distortion to form a reoriented image;

horizontally and vertically aligning the reoriented image with the reference image to form a realigned image; and

extracting a watermark from the realigned image.

B² 2. (canceled)

3. (canceled)

4. (previously amended) A method for restoring a geometrically distorted copy of a reference image, said method comprising:

automatically determining a type and amount of distortion of said distorted copy; and

substantially reversing the distortion to form a reoriented image;

wherein the step of automatically determining includes:

composing a geometric alteration of the distorted copy by making the distorted copy the same size as the reference image;

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1 defining a safe area having safe pixels, wherein said safe
2 area is an intersection of pixels in the reference image
3 with pixels in the geometric alteration, and said safe
4 pixels includes any pixel from the reference image or the
5 geometric alteration which lies in the safe area;

6 selecting 'n' points in the safe area, wherein 'n' is at
7 least three and not all 'n' points lie on a straight line;

8 building a list of 'n' reference centers, wherein each
9 reference center corresponds to coordinates of a particular
10 pixel lying closest to a particular one of said 'n' points;

11 constituting a plurality of pairs of sub-images, wherein
12 each pair is centered at one of said reference centers and
13 each pair is formed by a sub-image from the geometric
14 alteration and a corresponding sub-image from the reference
15 image;

16 minimally horizontally and vertically positioning from an
17 original sub-image position to a new sub-image position any
18 sub-image pair having any sub-image pixel lying outside the
19 safe area, such that said any sub-image pixel lies within
20 the safe area;

21 adjusting the reference center of said any sub-image pair to
22 correspond to said new sub-image position;

23 computing a two-dimensional cross correlation surface from
24 each of the 'n' pairs;

25 locating a horizontal, p_n , and a vertical, q_n , coordinate
26 offset of the greatest peak on each cross-correlation
27 surface;

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1 calculating a plurality of distorted centers;

2 using the adjusted centers and the corresponding distorted

3 centers to compute the coefficients matrix, A, of a pixel

4 position interpolation equation; and

5 forming a sub-matrix, S_A , from the first, second, fourth and

6 fifth elements of the matrix A.

7 5. (original) A method as recited in claim 4, further

8 comprising:

9 computing a set of proposed reference centers based on the

10 distorted reference centers and the pixel position interpolation

11 equations;

12 computing the Euclidean distances between the proposed reference

13 centers and the adjusted centers;

14 testing each Euclidean distances to determine if said each

15 Euclidean distance is statistically improbable;

16 discarding said each distorted center and its corresponding

17 adjusted center that define a Euclidean distance that is

18 statistically improbable while retaining at least three

19 not-discarded distorted centers and their corresponding adjusted

20 centers; and

21 recomputing the coefficients matrix, A, of a pixel position

22 interpolation equation using the at least three not-discarded

23 distorted centers and corresponding adjusted centers.

24 6. (original) A method as recited in claim 4, wherein the steps

25 of substantially reversing includes:

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- 1 factoring the sub-matrix S_A into four primitive image
2 manipulation matrices;
- 3 applying the four primitive image manipulation matrices to the
4 geometric alteration to produce a reoriented image;
- 5 making the geometric alteration identical to the reoriented image
6 if any primitive image manipulation matrix produces a distortion
7 greater than a predetermined threshold, said distortion
8 determined by examining all iteration-to-iteration incremental
9 changes in the Euclidean distances; and
- 10 repeating all the steps of claim 4 except the step of composing,
11 all the steps of claim 5, and the steps of factoring, applying
12 and making until no primitive image manipulation matrix produces
13 a distortion greater than the predetermined threshold.
- 14 7. (original) A method, as recited in claim 4, wherein the step
15 of horizontally and vertically aligning includes translating
16 horizontally the reoriented image by the value of the third
17 coefficient of the matrix, A, and translating vertically the
18 reoriented image by the value of the sixth coefficient of the
19 matrix, A, to form the realigned image.
- 20 8. (previously amended) A method as recited in claim 1, wherein
21 the step of composing includes:
- 22 shrinking or enlarging the distorted copy vertically by pixel
23 interpolation or extrapolation such that the produced geometric
24 alteration has a same height as the reference image, and
- 25 shrinking or enlarging the produced geometric alteration
26 horizontally by pixel interpolation or extrapolation to have the
27 same width as the reference image.

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1 9. (original) A method as recited in claim 4, wherein the
2 coordinate offsets are non-integers and the step of locating
3 includes using interpolation.

4 10. (original) A method, as recited in claim 1, wherein the
5 reference image is an original unmarked image.

6 11. (original) A method as recited in claim 4, wherein the step
7 of computing includes:

8 comparing a region in the geometric alteration surrounding each
9 of said reference centers with regions in the reference image
10 shifted in position by a multiplicity of coordinate offsets;

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11 ascertaining horizontal and vertical coordinate offsets of each
12 selected reference center as being the horizontal and vertical
13 offset at which the region in the geometric alteration and the
14 region on the reference image most nearly match; and

15 calculating the distorted centers from the coordinate offsets and
16 the corresponding reference centers.

17 12. (original) A method as recited in claim 11, wherein the step
18 of comparing includes:

19 using a modified cross correlation function in which the Fourier
20 transform of the cross correlation function is computed, wherein
21 magnitudes of the Fourier transform coefficients are modified to
22 make said magnitudes uniform, and

23 using an inverse Fourier transform to compute the modified
24 correlation function.

25 13. (original) A method as recited in claim 11, wherein the step
26 of comparing includes:

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1 using a weighted cross correlation function in which the Fourier
2 transform of the cross correlation function is computed, wherein
3 a weighted sum of the ordinary and modified Fourier transform
4 coefficients is formed, and

5 using an inverse Fourier transform to compute the weighted
6 correlation function.

7 14. (currently amended) A method ~~as recited in claim 8~~, for
8 restoring a geometrically distorted copy of a reference image,
9 said method comprising:

10 automatically determining a type and amount of distortion of said
11 distorted copy; and

12 substantially reversing the distortion to form a reoriented
13 image.

14 wherein the step of composing includes:

15 shrinking or enlarging the distorted copy vertically by
16 pixel interpolation or extrapolation such that the produced
17 geometric alteration has a same height as the reference
18 image, and

19 shrinking or enlarging the produced geometric alteration
20 horizontally by pixel interpolation or extrapolation to have
21 the same width as the reference image; and

22 wherein the step of ascertaining includes:

23 composing a geometric alteration of the distorted copy by
24 making the distorted copy the same size as the reference
25 image;

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1 defining a safe area having safe pixels, wherein said safe
2 area is an intersection of pixels in the reference image
3 with pixels in the geometric alteration, and said safe
4 pixels includes any pixel from the reference image or the
5 geometric alteration which lies in the safe area;

6 building a list of reference centers, wherein each reference
7 center corresponds to coordinates of a particular pixel in
8 the safe area lying closest to a particular one of said at
9 least three pixel locations;

10 computing a plurality of corresponding distorted centers;

B 11 using the reference centers and the corresponding distorted
12 centers to compute coefficients of a matrix, A, of pixel
13 position interpolation equations;

14 testing each distorted center to determine if said each
15 distorted center is statistically improbable; and

16 discarding each distorted center that is statistically
17 improbable while retaining at least three not-discarded
18 distorted centers, until no more distorted centers are
19 discarded.

20 15. (currently amended) An article of manufacture comprising a
21 computer usable medium having computer readable program code
22 means embodied therein for causing a restoring of a geometrically
23 distorted copy of a reference image, the computer readable
24 program code means in said article of manufacture comprising
25 computer readable program code means for causing a computer to
26 effect:

27 automatically determining a type and amount of distortion of said
28 distorted copy, without extracting a registration signal;

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1 substantially reversing the distortion to form a reoriented
2 image;

3 aligning the reoriented image with the reference image to form a
4 realigned image; and

5 extracting a watermark from the realigned image.

6 16. (canceled)

7 17. (canceled)

B 8 18. (original) An article of manufacture as recited in claim 15,
9 wherein the reference image is a copy of an original unmarked
10 image.

11 19. (original) An article of manufacture as recited in claim 15,
12 wherein the step of automatically determining includes:

13 selecting a set of at least three reference centers in the
14 geometric alteration;

15 comparing a region in the geometric alteration surrounding each
16 of said reference centers, with regions in the reference image
17 shifted in position by a multiplicity of coordinate offsets;

18 ascertaining horizontal and vertical coordinate offsets of each
19 selected reference centers as being the horizontal and vertical
20 offset at which the region in the geometric alteration and the
21 region on the reference image most nearly match; and

22 determining the type and amount of distortion from the coordinate
23 offsets and the set of reference centers.

24 20. (original) An article of manufacture as recited in claim 19,
25 wherein the step of comparing includes:

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1 using a modified correlation function in which the Fourier
2 transform of the correlation function is computed, wherein the
3 magnitudes of the Fourier transform coefficients are modified to
4 make said magnitudes uniform, and

5 using an inverse Fourier transform to compute the modified
6 correlation function.

7 21. (original) An article of manufacture as recited in claim 19,
8 wherein the step of ascertaining includes performing a
9 least-squares fit on the horizontal and vertical coordinate
10 offsets of the set of reference centers.

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11 22. (currently amended) A computer program product comprising a
12 computer usable medium having computer readable program code
13 means embodied therein for causing a readjusting of a
14 geometrically distorted copy of a reference image, the computer
15 readable program code means in said computer program product
16 comprising computer readable program code means for causing a
17 computer to effect:

18 automatically determining a type and amount of distortion of said
19 distorted copy, without extracting a registration signal;

20 substantially reversing the distortion to form a reoriented
21 image;

22 horizontally and vertically aligning the reoriented image with
23 the reference image to form a realigned image; and

24 extracting a watermark from the realigned image.

25 23. (currently amended) An apparatus for restoring a
26 geometrically distorted copy of a reference image, said method
27 comprising:

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1 means for automatically determining a type and amount of
2 distortion of said distorted copy, without extracting a
3 registration signal;

4 means for substantially reversing the distortion to form a
5 reoriented image;

6 means for horizontally and vertically aligning the reoriented
7 image with the reference image to form a realigned image, and

8 means for extracting a watermark from the realigned image.

B2 9 24. (canceled)

10 25. (canceled)

11 26. (currently amended) An apparatus ~~as recited in claim 23~~, for
12 restoring a geometrically distorted copy of a reference image,
13 said method comprising:

14 means for automatically determining a type and amount of
15 distortion of said distorted copy, and

16 means for substantially reversing the distortion to form a
17 reoriented image;

18 wherein the means for automatically determining includes:

19 means for composing a geometric alteration of the distorted
20 copy by making the distorted copy the same size as the
21 reference image;

22 means for defining a safe area having safe pixels, wherein
23 said safe area is an intersection of pixels in the reference
24 image with pixels in the geometric alteration, and said safe

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1 pixels includes any pixel from the reference image or the
2 geometric alteration which lies in the safe area;

3 means for selecting 'n' points in the safe area, wherein 'n'
4 is at least three and not all 'n' points lie on a straight
5 line;

6 means for building a list of 'n' reference centers, wherein
7 each reference center corresponds to coordinates of a
8 particular pixel lying closest to a particular one of said
9 'n' points;

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10 means for constituting a plurality of pairs of sub-images,
11 wherein each pair is centered at one of said reference
12 centers and each pair is formed by a sub-image from the
13 geometric alteration and a corresponding sub-image from the
14 reference image;

15 means for minimally horizontally and vertically positioning
16 from an original sub-image position to a new sub-image
17 position any sub-image pair having any sub-image pixel lying
18 outside the safe area, such that said any sub-image pixel
19 lies within the safe area;

20 means for adjusting the reference center of said any
21 sub-image pair to correspond to said new sub-image position;

22 means for computing a two-dimensional cross correlation
23 surface from each of the 'n' pairs;

24 means for locating a horizontal, p_n , and a vertical, q_n ,
25 coordinate offset of the greatest peak on each
26 cross-correlation surface;

27 means for calculating a plurality of distorted centers;

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1 means for using the adjusted centers and the corresponding
2 distorted centers to compute the coefficients matrix, A, of
3 a pixel position interpolation equation; and

4 means for forming a sub-matrix, S_A , from the first, second,
5 fourth and fifth elements of the matrix A.

6 27. (original) An apparatus as recited in claim 26, further
7 comprising:

8 means for computing a set of proposed reference centers based on
9 the distorted reference centers and the pixel position
10 interpolation equations;

11 means for computing the Euclidean distances between the proposed
12 reference centers and the adjusted centers;

13 means for testing each Euclidean distances to determine if said
14 each Euclidean distance is statistically improbable;

15 means for discarding said each distorted center and its
16 corresponding adjusted center that define a Euclidean distance
17 that is statistically improbable while retaining at least three
18 not-discarded distorted centers and their corresponding adjusted
19 centers; and

20 means for recomputing the coefficients matrix, A, of a pixel
21 position interpolation equation using the at least three
22 not-discarded distorted centers and corresponding adjusted
23 centers.

24 28. (original) An apparatus as recited in claim 26, wherein the
25 coordinate offsets are non-integers, and the means for locating
26 includes using interpolation.

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1 29. (currently amended) A method ~~as recited in claim 1~~, for
2 restoring a geometrically distorted copy of a reference image,
3 said method comprising:

4 automatically determining a type and amount of distortion of said
5 distorted copy; and

6 substantially reversing the distortion to form a reoriented
7 image;

8 wherein the steps of automatically determining and substantially
9 reversing are repeatedly applied until an amount of the
10 distortion falls below a given threshold

11 30. A method as recited in claim 29, wherein the given threshold
12 is less than a 0.5 pixel spacing.

13 31. (currently amended) A method comprising:

14 automatically measuring the degree of distortion
15 imparted upon a distorted replica of an original
16 image, without extracting a registration signal;

17 substantially reversing the degree of distortion of
18 the distorted replica to form an undistorted image;
19 and

20 aligning the undistorted image with the original
21 image; and

22 extracting a watermark from the realigned image.

23 32. (original) A method as recited in claim 31, further
24 comprising determining whether the distorted replica image has

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1 been geometrically distorted relative to another form of the
2 original image.

3 33. (currently amended) An article of manufacture comprising a
4 computer usable medium having computer readable program code
5 means embodied therein for causing watermark extraction from an
6 image, the computer readable program code means in said article
7 of manufacture comprising computer readable program code means
8 for causing a computer to effect:

9 automatically measuring the degree of distortion
10 imparted upon a distorted replica of an original
11 image, without extracting a registration signal;

12 substantially reversing the degree of distortion of
13 the distorted replica to form an undistorted image;
14 and

15 aligning the undistorted image with the original
16 image; and

17 extracting a watermark from the realigned image.

18 34. (previously amended) An article of manufacture as recited in
19 claim 33, the computer readable program code means in said
20 article of manufacture further comprising computer readable
21 program code means for causing a computer to effect determining
22 whether the distorted replica image has been geometrically
23 distorted relative to another form of the original image.

24 35. (original) A method as recited in claim 4, wherein the step
25 of selecting 'n' points includes employing a simulated mesh with
26 knots.